CROSS-ACCLIMATIZATION BETWEEN BODY TRAINING AND ALTITUDE TOLERANCE

E.D. Voight

Translation of "Gekreuzte Anpassung zwischen körperlichem Training und Höhentoleranz", In: Beitrage zur Weltraumbiologie und Biophysik (Contributions to Space Biology and Biophysics). Deutsche Versuchsanstalt fuer Luft- und Raumfahrt, Bad Godesberg (West Germany), Report DLR-FB-68-24, (Meeting of Extraterrestrial Biophysics and Biology., Frankfurt am Main, 26-27 Oct. 1966), Apr. 1968, pp. 49-56.

(NASA-TT-F-15434) CROSS-ACCLIMATIZATION BETWEEN BODY TRAINING AND ALTITUDE TOLERANCE (Scientific Translation Service) 10 p HC $4.00 CSCL 05E N74-19760
9 G3/05 33539 Unclas

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546 APRIL 1974

CROSS-ACCLIMATIZATION BETWEEN BODY TRAINING AND ALTITUDE TOLERANCE

E. D. Voight

We shall report on a set of investigations which were not /49* stimulated by problems from the space medicine field. Nevertheless, we can easily establish relations with the theme of the meeting.

Cross-adaptation to various stressors has received attention for many years. Both positive and negative adaptation have been observed with different combinations of stress-causing factors.

When Mexico City was selected as the site of the 1968 Olympic Games, the problem of the most practical training preparation with respect to altitude acclimatization emerged immediately for sports physiologists and trainers. Long-term acclimatization and repeated shorter exposures for periods of 2 - 3 weeks were discussed. It became quite generally apparent from this special problem of physical capacity under reduced oxygen pressure that although there was much material about the effects of oxygen dificiency at pressures below 70 Torr, and about adaptation methods, there was very little information about this very special but suddenly real problem. In the meantime, some of the countries interested in the performing sports had introduced comprehensive research plans.

In the following, we shall report on a series of studies which were stimulated by the questions which appeared. The reaction of the adrenal cortex to the combined stressors of

---

* Numbers in the margin indicate pagination in the original foreign text.

oxygen deficiency and physical training appeared interesting to us. In the past year we had opportunity to carry out studies on /50
racing oarsmen, along with Wegmann, Brüner and Klein at the Institute for Flight Medicine of the DVL in Bad Godesberg. The subjects were the crew of the Ratzeburg Eight, which had attained prominence through international success.

In detail, the study program consisted of exposing the rowers in a reduced-pressure chamber to a definite stress situation, which was a half hour of oxygen-deficient breathing corresponding to an altitude of 6,900 m. It had appeared in previous studies that on the average, good reaction of the adrenal cortex to acute oxygen deficiency occurred only at this low pressure. This was the basis of the intention, to shock the system with a substantial exogenous stress situation and to measure the reaction.

Venous blood was drawn at the beginning of the experiment, at the end of oxygen-deficient breathing, after 30 minutes, and after one hour, to determine plasma corticoids, the transaminases GOT and GTP, MDH, and the total ATP content. In addition, although we shall not report on the findings now, we also determined, after a definite time interval, the capacity pulse index according to Müller and the maximum O_2 uptake according to Astrand, estimated from submaximal work on the bicycle ergometer, both at high oxygen and, on the following day, in the low-pressure chamber at an equivalent height of 3,000 m. All the control and supplementary studies were repeated at the same time of day to eliminate variations in the circadian rhythm.

This program was performed twice in all. The first time was in the winter, during a relative rest in training when only force training was being done. The second time was directly in connection with the German Championship, which they won.

Therefore, one can hardly raise any doubts about the improvement in their condition as compared to the winter.

Studies could not be done on one member of the crew because of excessive difficulties with pressure compensation in the middle ear. From a previous series of studies on 16 healthy students we had obtained comparative values for normal persons of the same age, so that the results obtained in the well-trained state could be referred both to the actual starting value and to a comparative group. / 51

Discussion of the results

The resting level of 17-hydroxycorticosteroids is distinctly lower in normal persons than in the athletes. But even for the athletes, the plasma level differs. It is higher in training than during the winter break. In each case, excretion of adrenal cortex hormones increases as a reaction to stress. This occurs relatively quickly, apparently, because the greatest changes always appeared at the end of the stress situation, only half an hour after the beginning. By an hour later, the increased corticoid level was decreasing.

The extent of the rise in the plasma level is also variable. The high-performance athletes have excreted much more than the non-athletes.

Study of the ATP level in whole blood gave the following results: here, too, the resting level is higher for athletes than for non-athletes. But it is at best conjecturable that there is a relation with the state of training. The difference is not statistically significant. The non-athletes show no reaction to the stress. The reaction is about the same magnitude for the athletes, independent of the state of training, so that the

blood level remains constant during the period of observation.

Differences in the other studies were not statistically significant, so that we shall not report on them.

Discussion / 52

Production of corticosteroids, and, therefore, the function of the adrenal cortex, is of extreme importance for the organism to adapt to and master various stresses. It is a generally recognized opinion that the elimination of the adrenal cortical hormones is a controlled process. That is, it is part of a control loop, although we do not yet know its structure in detail, either qualitatively or quantitatively. On the other hand, we can already make statements on separate elements of the control loop, such as the reaction of the adrenal cortex. Apparently the adrenal cortical hormones have the function of a final control element. If one stresses the system with a step function of the input quantities, as can be realized well through acute oxygen deficiency with a distinct beginning and constant magnitude, then we can make some orienting statements about the dead time and delay of the control loop as far as the control element. They must be quite short, because preliminary studies showed that the plasma corticosteroids had risen to 3/4 of their level at the end of the stress after only 10 minutes. No series of studies was done with closer time resolution, and the range of error in the method would also soon set limits to the necessary accuracy.

The decaying portion after the end of the disturbance is very important for study of the control characteristics; but we believed that we could leave out a more extensive study. We were considering only one element of the whole control loop here, and also determined only the balance with our method, and not the separate rates of formation and elimination. But in all cases,

testing of the value an hour after the end of the experiment established that the deviation had already decayed, so that the dead time and decay are quite short. Therefore, the two values before and at the end of the stress situation had the greatest importance.

There was a significant difference in the resting plasma corticoid level for the three groups. It was highest for the trained athletes and lowest for the non-athletes. There is also a relation to the physical activity which is also dependent on the state of training. This increased resting level can be understood as a response to the strong physical work which acts as a stress situation. Adaptation to this stress, that is, the training process, is expressed, then, in a still further increased resting coricoid level. / 53

The other stressor used in the experiment was oxygen deficiency. It always resulted in a rise of the corticoid level. The magnitude of the rise differed for the various groups. The differing reaction was most clearly expressed between non-athletes and athletes during the winter. The rise was almost twice as great for the athletes. The only difference between the two groups was in the extent of previous athletic activity. One group had performed extensively in sports, but at the time of the study, they could not be considered as highly trained. The other group had not previously participated in any performing sport, and this was their only difference from the other group. Therefore, the previous adaptation to performing sports gained in some training periods led to different reactions on another stress situation. This can be designated as "positive cross-adaptation".

Of course, it was necessary to investigate whether oxygen deficiency and physical work did not have the same basic effects, so that these two forms of stress would not be two different stressors at all. But some important differences can be established, which justify separation. In athletes, for instance, there is no reduction of the arterial oxygen saturation. The limiting circulatory factory for capacity is predominantly locally in the working musculature. The other organs have no oxygen deficiency. With oxygen-deficient breathing, in contrast, there is a decrease in the arterial p_{O_2}. This certainly different for /54 oxygen deficiency than for physical work.

The results of the ATP study in whole blood likewise suggest cross-adaptation. Here, too, the resting blood level showed dependence on the degree of body activity, being highest for the trained athletes. No change occurred during oxygen deficiency for the non-athletes. For the athletes, in contrast, there was a significant rise which was independent of the training status. We shall not attempt to explain this finding here, because it must be of a very hypothetical character. But the fact that membership in groups which are or are not adapted to physical work is decisive for the different reaction to acute oxygen deficiency again allows us to apply the concept of cross-adaptation.

Attention should be paid to cross-acclimatization with respect to the training preparations for Mexico. For some years, long-distance runners who live and train in high country have drawn attention to this phenomenon through outstanding performances at sea level. The Ratzeburg Eight, somewhat surprisingly, won the European championship again this year, with a crew which had changed in the meantime. Just before, they had finished a three-week training camp on the Kaprun reservoir at 2,000 m altitude, finally attaining the same times as they had done previously at sea level.

REFERENCES

1. Brüner, H., D. Jovy and K.E. Klein. Hypoxia As a Stressor. "Aerospace Medicine", Vol. 32, 1961, pp. 1009 - 1018.

2. Fleischner, J.R. and F. Sargent. Effects of Heat and Cold: Crossed Resistance or Crossed Sensitization. "J. Appl. Physiol.", Vol. 14, 1959, pp. 789 - 797.

3. Fregly, M.J. Cross-Acclimatization Between Cold and Altitude in Rats. "Amer. J. Physiol.", Vol. 176, 1953, pp. 267 - 274.

4. Jovy, D., H. Brüner and K.E. Klein. The Problem of Cross Adaptation in Man. Aerospace Medical Panel Meeting der AGARD, Athens, 1963.

5. Jovy, D., H. Brüner and K.E. Klein. Adaptive Responses of Adrenal Cortex to Some Environmental Stressors, Exercise and Acceleration. Proc. 1st Int. Congr. on Hormonal Steriods. New York: Academic Press, 1965.

6. Klein, K.E., H. Brüner, D. Jovy and H.M. Wegmann. Alterations of Vegetative Hormonal Stress Responses in Man Following Adaptation. Int. Aeronautical and Cosmonaut. Med. Congr., Madrid, 1962.

7. Klein, K.E., H. Brüner, D. Jovy and H.M. Wegmann. Adaptation to Various Loads During Space Flight. WGLR yearbook, 1963.

8. Klein, K.E., J. Eichhorn, Kl. Schalkhäuser, J. Schotte, E.D. Voight and H.M. Wegmann. Comparative Investigations of Body Muscle Performance of Humans with Oxygen Deficiency and Acceleration. "Int. Z. angew. Physiol.", Vol. 22, 1966, p. 190.

9. McLaughlin, J., T.J. Kaniecki and I. Gray. "Anal. Chem.", Vol. 30, 1958, p. 1517.

10. Stickney, J.C. and E.J. Van Liere. Acclimatization to Low Tension. "Physiol. Rev.", Vol. 33, 1953, pp. 13 - 34.

11. Wegmann, H.M., H. Brüner, D. Jovy and K.E. Klein. Changes of Enzyme Activities in Serum as an Indication of Unspecific Adaptation. Int. Aeronautical and Cosmonaut. Med. Congr., Rome, 1963.

Translated for National Aeronautics and Space Administration under contract No. NASw 2483, by SCITRAN, P.O. Box 5456, Santa Barbara, California, 93108

STANDARD TITLE PAGE

1. Report No. NASA TT F-15,434	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Cross-Acclimatization between body training and altitude tolerance		5. Report Date April, 1974
		6. Performing Organization Code
7. Author(s) E. D. Voight		8. Performing Organization Report No.
		10. Work Unit No.
9. Performing Organization Name and Address SCITRAN Box 5456 Santa Barbara, CA 93108		11. Contract or Grant No. NASw-2483
		13. Type of Report and Period Covered Translation
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546		14. Sponsoring Agency Code

15. Supplementary Notes "Gekreuzte Anpassung zwischen körperlichem Training und Höhentoleranz", In Beitrage zur Weltraumbiologie und Biophysik (Contributions to Space Biology and Biophysics). Deutsche Versuchsanstalt fuer Luft- und Raumfahrt, Bad Godesberg (West Germany), Report DLR-FB-68-24, (Meeting of Extraterrestrial Biophysics and Biology., Frankfurt am Main, 26-27 Oct. 1966), Apr. 1968, pp. 49-56.

16. Abstract

Cross-acclimatization between physical training and oxygen deficiency is indicated by measurements of adrenal corticosteroid levels in rowers in and out of training and in non-athletes before during, and after exposure in an altitude chamber at a pressure equivalent to 6,900 m. Blood ATP measurements agree, but are less significant.

17. Key Words (Selected by Author(s))	18. Distribution Statement
	Unclassified - Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	89	4.00